



Earthquake - 301

Install a gas safety cut-off valve

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.



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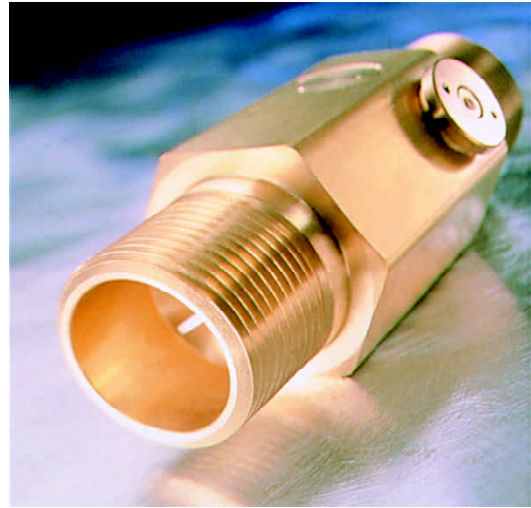
Potential Hazard



An earthquake is movement of the earth's crust that causes the ground to shake or tremble. As a result, earthquakes often damage gas pipes. Gas pipes can be damaged from even minor earthquakes when they crack or split, or when your appliances shake or are knocked over because your home shifts. Then natural or propane gas may escape into your house and create a serious threat of fire or an explosion. Injuries to you, your family, your home, your neighbors, and the environment may result.

Mitigation Measure

If you are replacing a portable kerosene heater or putting in bottled or tank based propane or natural gas heating systems, then a gas safety cut-off valve is an appropriate and good low-cost mitigation measure for reducing the risks of a gas leak into your home. One such device is the Sanders Safety Cut-Off Valve, which is installed on your gas pipe outside the home. The Sanders Valve has been approved by the American Gas Association. This self-contained, one-inch valve fits on the low-pressure side of the regulator leading to a gas pipe. Its spring stops the flow of gas whenever there is a break in the pipe or a drop in gas pressure, which may happen when there is an accident or natural disaster. Because the valve is placed in-line above ground, it is easy to determine if a home already has one installed. One needs only to find the gas meter or propane tank and see if the valve is in line near to the meter or the tank.



Installing the valve has many benefits to you. It shuts off the gas flow at the first sign of a gas pipe break or pressure drop, and the valve remains closed until inspection and repairs have

been completed. Thus it removes the danger of gas escaping into your home and causing a fire or explosion. The valve does not require any special attention from you because it automatically resets after repairs have been made. Also, it is weather resistant and does not require any power to operate, so it is very cost-effective. Because it is adaptable to a wide range of situations, it can be installed without any digging on your property.



Besides providing protection during an earthquake, the cut-off valve also provides protection for pipes damaged during a flood.

To assemble, install, or service the Sanders Safety Cut-Off Valve, a state-certified plumbing and heating technician or gas utility technician will be required. It should be noted that the valve will work for high or low pressure systems and is easily set.



Earthquake - 302

Brace your manufactured home

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.



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Potential Hazard

Manufactured homes and modular buildings not attached to permanent foundations need special consideration when located in earthquake-prone areas. These structures can slide or

topple off their foundations if not properly secured to resist shaking and require reinstallation. Manufactured homes are seldom destroyed by earthquakes; however, they are often damaged. Even moderate earthquakes may dislodge these homes from their support system (piers), allowing them to fall to the ground. Accessory structures such as awnings, decks, skirting, etc., are racked and twisted beyond repair when the home shifts off the support piers. Earthquake-related fires are usually the cause of destroyed manufactured homes during



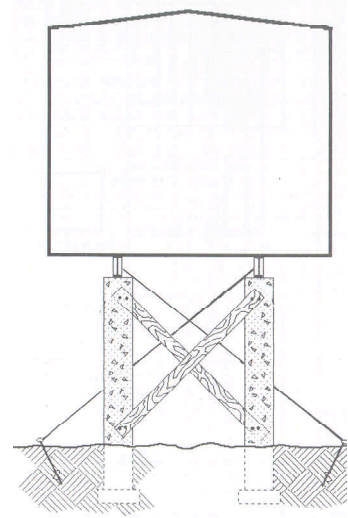
earthquakes. Fires typically originate from a ruptured gas line where it connects to the home or to an appliance. Manufactured homes are required to have gas lines secured in place. However, many times when a homeowner replaces appliances, they are not secured and become the source of ignition when the gas connection is broken or ruptured by earthquake shaking.

Mitigation Measure

Special earthquake stabilizing devices for manufactured homes are available. Check with earthquake retrofit specialists in your area. These devices have proved to be effective in preventing or minimizing damage in several recent earthquakes.

Structural engineers advise that four precautions will improve the earthquake readiness of a manufactured home. Keep the axle, wheels, and inflated tires on the unit; reduce interior hazards in the same way as for other housing; install an earthquake safety device to keep the unit from falling off its supports; and install an automatic gas shutoff valve (Fact Sheet 301).

Many states have different requirements for bracing. You should contact your local Housing and Community Development office for more details. However, the California Department of Housing and Community Development (HCD) certifies Earthquake Resistant Bracing Systems for manufactured homes. These systems have been found to substantially reduce damage to homes from earthquakes. Manufactured homes can be secured in several ways. You can secure the base directly to the ground or use ties (rust-resistant straps or cables) that go over the top of your home. The ties are held into the ground by anchors whose embedded length and type should be selected for the applicable soil type. See FEMA 85 – *Manufactured Home Installation in Flood Hazard Areas* for more information.



A manufactured home elevated on piers, piles, blocks, stub walls or wood should be braced and anchored appropriately for the soil type. There are two common methods of bracing or securing a manufactured home. Knee bracing can be wood cross pieces or wire straps attached to the horizontal beam supporting the home. Diagonal bracing uses wooden or steel rods and provides even greater stability.



Earthquake - 303

Bolt your house sill plate connection

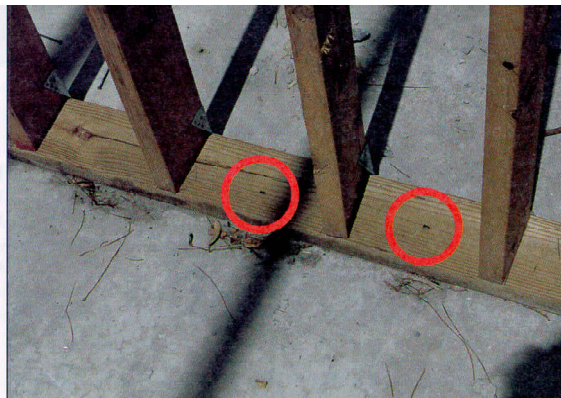
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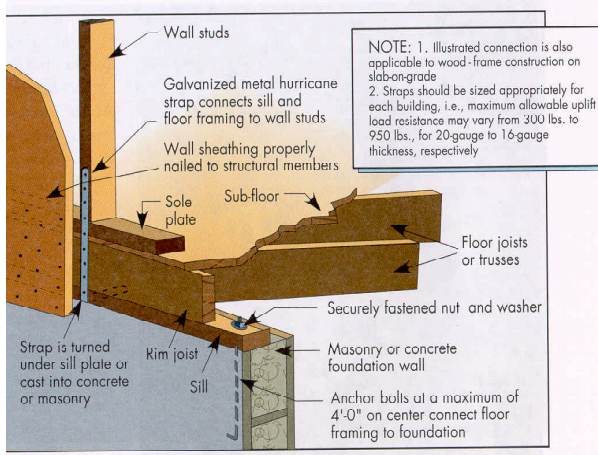
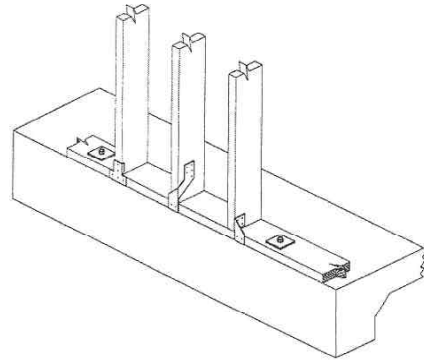
Potential Hazard

The sill plate of a house rests directly on top of its foundation. It is usually a wooden 2"x 6" or 2"x4" board that runs the length of the foundation upon which the floor or cripple wall of a home stands. If the sill plate for your home is built on a cripple wall and crawl space foundation, your house will be especially susceptible to earthquake damage. If the sill plate is not securely anchored, an earthquake can cause it to shift on the foundation. When this shifting occurs, there is a significant potential for severe damage to your home as well as injury to you and members of your family. The picture to the left illustrates an inadequately secured foundation that used nails instead of bolts.



Mitigation Measure

The best protection from problems associated with your home's shifting is to secure your house to the ground or to a heavy concrete foundation. This action will transfer lateral loads from the walls of your home to its foundation. First, one must determine if the sill plate has already been secured. To conduct an inspection if the house rests upon a cripple wall, you will need access to the crawl space under the house. Upon entering the crawl space, look for evidence of bolts going through the wood sill and into the foundation. A home on a conventional foundation is a little harder to inspect. Not infrequently, however, is it possible to perform a limited inspection. Sometimes you can remove the ventilation screens and, using a flashlight, visually inspect the area where the sill plate meets the foundation.



A typical single family home should be secured to its foundation through its wooden sill or base plate with $\frac{1}{2}$ " diameter anchor bolts which penetrate several inches into the foundation and are spaced at four feet or less along the base of the exterior walls. This method is not limited to cripple wall construction; it can also be used for a house built on a basement or slab-on-grade foundation or on another type of crawl space foundation.





Earthquake - 304

Brace your cripple walls

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.



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Potential Hazard

A cripple wall is a short wall between the foundation and its main structure. The cripple wall is usually between one to two feet high. This usually means that the home has a crawl space underneath. This cripple wall supports the floor and exterior walls. An unbraced cripple wall can shift during an earthquake and the house could fall off its foundation. Even a minor earthquake can cause the cripple wall to crack, buckle, or crumble, thus undermining the home's stability. If your house is built on a cripple wall foundation, brace the cripple wall to increase your home's structural stability and reduce earthquake damage.



Mitigation Measure

Diagram illustrating the construction of a new block at the top and bottom of a cripple wall. The diagram shows the exterior siding, existing blocking between joists, subfloor, floor joist, new plywood or oriented strand board, new block at top and bottom of cripple wall, sill plate, and foundation.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



Earthquake - 305

Brace your masonry chimney

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.

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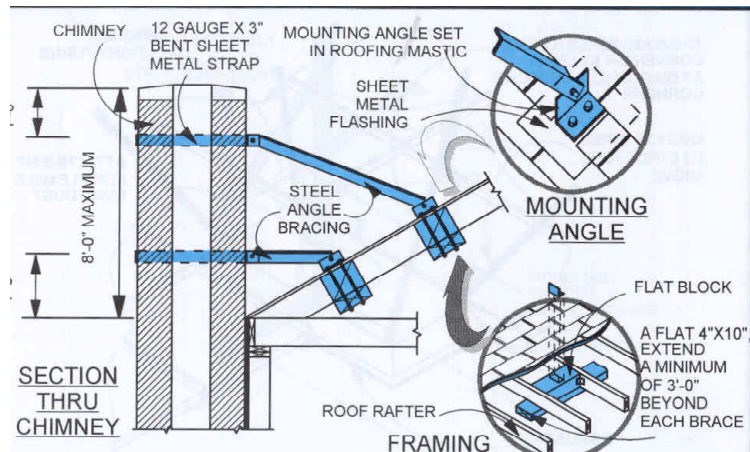


Chimneys installed before 1960 may not be properly reinforced and tied to the building. Be especially careful about very tall chimneys, which could fall in the direction of an exit path. Or worse, the chimney could fall onto the home. Usually when this happens to brick chimneys, the heavy weight crashes through the roof and into the home as illustrated by the picture above. When checking the chimney to see if it is already strapped, be careful not to confuse strapping used to secure an

antenna as straps used as part of chimney bracing like in the photo to the left.

Mitigation Measure

To protect the investment you made to the roof like insulation, strengthened roof sheathing, or truss bracing, increase the security of your masonry chimney. If the top of the chimney is flush with the roof, the chimney is probably not worth retrofitting because of its decreased likelihood of falling. Chimneys that extend beyond the roof line should be secured in high earthquake risk areas. To increase the safety of your chimney during an earthquake, first reinforce the sub-roof around the chimney with 2"x4" boards that are perpendicular to the roof rafters or trusses. Use at least two 16d nails to secure it to each rafter and 1/2" diameter bolts to go through the roof into the added 2x4's. This shoring up is needed to anchor the chimney braces. Braces consist of 2" wide 16 gauge steel straps. At least two should be used – one at the top of the chimney and one at or just above the roof line. The straps are secured to the roof with angle 2"x2"x1/4" steel angle braces. Refer to the sketch above for a graphic illustration. This strapping should mitigate the shaking effects of earthquakes upon your chimney. Furthermore, be sure to seal the areas around where you have penetrated the roof with bolts.



After an earthquake, be sure to check and repair the chimney as needed.

Notes:



Earthquake - 306

Use flexible connections for gas and water

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.



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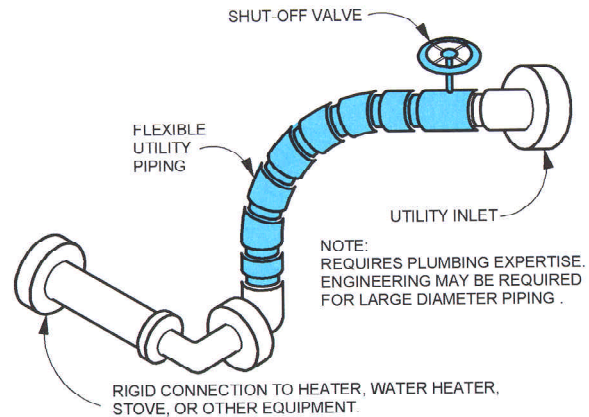


Most water and gas supply lines have rigid pipes and connections. These lines can be torn away or ruptured during an earthquake. The results could include not only serious damage to your house but also injury to you and members of your family. A broken water line can flood the house interior and damage appliances and furnishings. The water could also short circuit and start a fire. A broken gas line is especially serious because the escaping gas will slowly accumulate and could cause a

fire or explosion. Even if no explosion occurs, the gas will slowly displace breathable air and cause a life-threatening atmosphere.

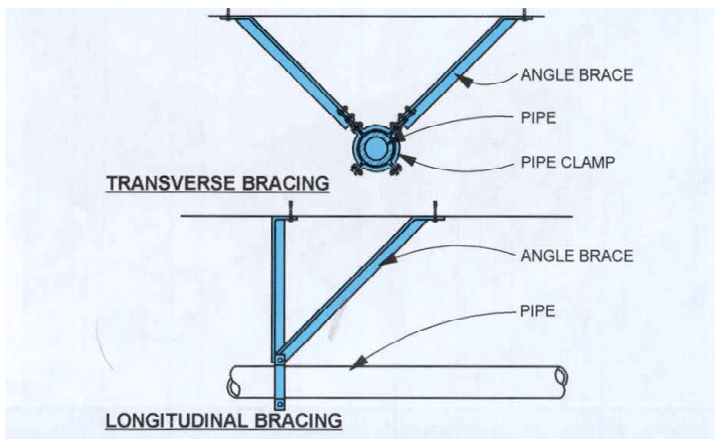
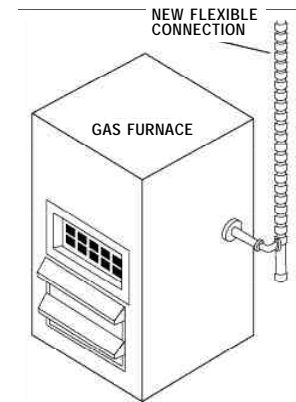
Mitigation Measure

One way to prevent broken gas and water lines is to have flexible connectors installed between appliances and their supply lines. The diagram shows a flexible connector installed on a gas furnace. You can also use a flexible connection for other appliances, such as a hot water heater, clothes dryer or stove. Only a licensed contractor should install this connection.



Flexible connectors will help reduce the risk of gas and water lines being damaged as a result of shaking during an earthquake. Installing flexible connectors should not be done instead of bracing or strapping. Flexible connectors will not help if an appliance, such as a water heater topples over; they will only help to mitigate the effects of shaking.

The supply pipes that connect to your appliances also need to be protected. This is a particularly simple mitigation measure when installing a new heating appliance or refurbishing an old one. Install brackets or angle bracing to keep the rigid pipes from moving as illustrated below.





Earthquake - 307

Strap your water heater

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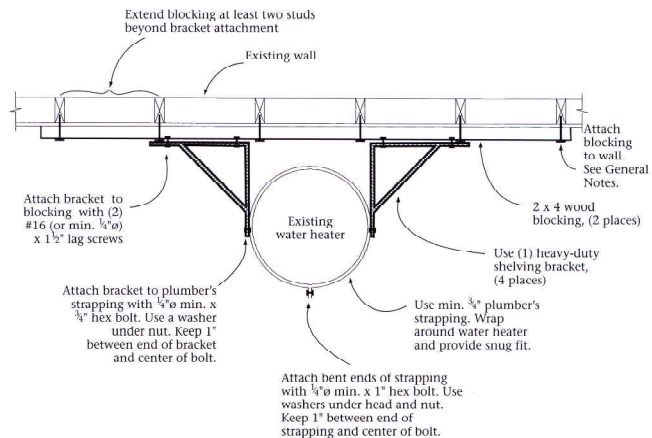
Potential Hazard



A standard water heater is the home appliance most likely to have earthquake damage because it has a high center of gravity. Although modern water heaters have been designed to be more stable than the early models, they are still likely to “walk” or even tip over during an earthquake. If this movement happens, your utility lines may be disconnected. The results may include gas or water leakage, electrical shorts, fires, or explosions. Also, if your water heater does tip over, you could lose one of your best sources of water for the period following the earthquake.

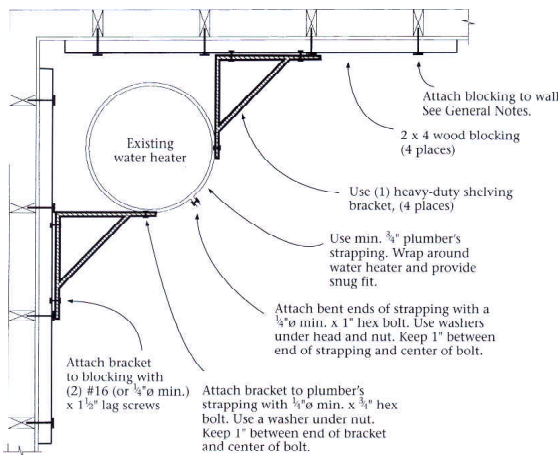
Mitigation Measure

To prevent the water heater from moving or tipping over, you need to secure it. Wrap steel plumber's tape around the entire heater at least twice. Then secure the tape to two different wall studs with 2" or longer lag screws. For added security, place blocking between the heater and the wall. This blocking could be a plywood "shelf" cut to fit the water heater's circular shape or a 2x4 or similar board behind the heater.



You should connect existing concrete or grouted masonry walls with concrete anchor bolts. There are many types, including wedge, expansion, sleeve, and epoxy. To take advantage of the full capacity of concrete anchors, space them at least 12 times the diameter of the bolt, with a minimum edge distance of 6 times the diameter. The minimum embedment length is typically 8 bolt diameters. The bolt will have a greatly reduced capacity if it is too close to an edge or an adjacent bolt or if it has insufficient embedment into the concrete. When drilling holes into concrete or masonry walls, avoid cutting any reinforcing steel (rebar) or electrical conduit by using a magnetic device to locate the steel or conduit.

The most common fasteners are wedge anchor bolts, where part of the shank expands to press against the sides of the hole as the nut is tightened. For anchorage to reinforced concrete walls, expansion anchors are the most common and easiest to install. Typical sizes for wall anchorage of non-structural items might be a 1/2" diameter A307 bolt with 4" minimum embedment, 5" edge distance, and 6" spacing. Use galvanized or preferably stainless steel bolts and other hardware where they will not be exposed to moisture, weathering or corrosion-resistant chains, eyebolts, quick-release safety hooks for gas cylinders, or other items stored outside or in a damp location.



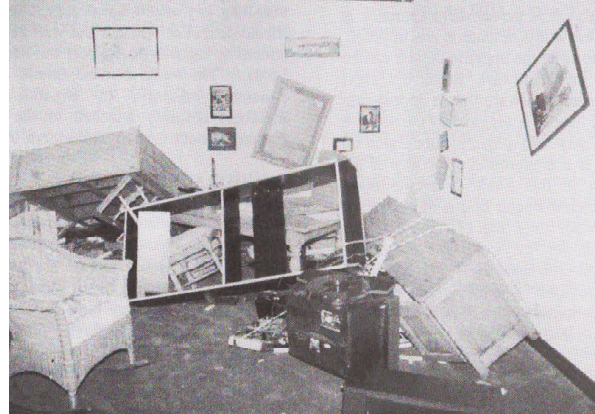
Sleeve anchors may be best for frequently moved items. Sleeve anchors consist of a threaded sleeve installed directly into the concrete, flush with the concrete surface, and a bolt that is screwed into the sleeve. When the bolt is removed, the sleeve is left flush with the wall or floor and without the bolt protruding. Epoxy anchors are inserted into slightly oversized holes with epoxy or polyester resin to hold the bolt in place.



Earthquake - 308

Secure your light home contents

Everyone knows an earthquake can cause great damage. Many people, however, believe that an earthquake will never occur near them or it is unlikely to occur in their lifetime. These people who are not aware of their potential risk may do little to help themselves. Unfortunately, these people often suffer severe consequences from even a minor tremor.



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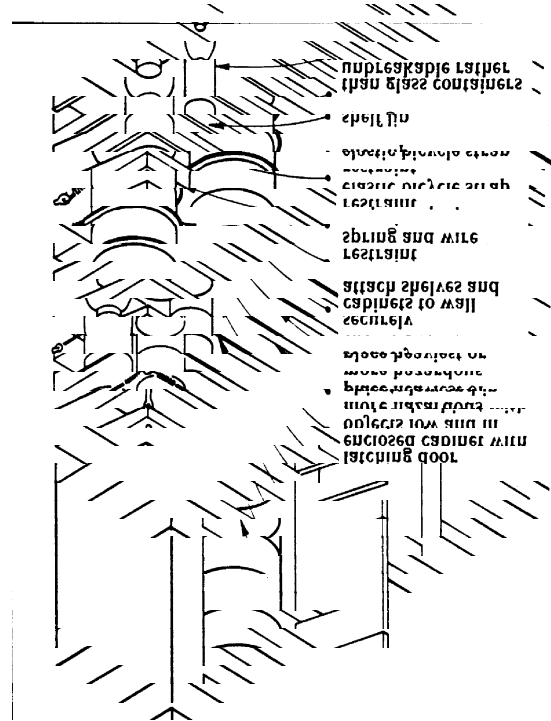


During an earthquake, falling objects could hit you and your family and cause serious injury. The strong shaking of your home may also break the glass in your home's windows and doors. The doors of your cabinets may open, so your china and other precious items fall out, and unprotected items on ordinary shelves will also fall off. Mirrors and picture glass also may break when falling from the walls. When these items hit the floor, they may shatter and spread dangerous shards everywhere. Drawers containing small objects may spill their contents on the floor. In the kitchen, these items are liable to be sharp and dangerous. Light fixtures supported by suspended ceiling grids can lose their vertical support

when the suspended ceiling sways and is distorted. Often electrical wires support pendant-mounted fixtures. When the wire splices pull apart, these fixtures also fall and break. When the fixtures swing, they can strike and break other objects. The result of the breakage will be that your home is filled with dangerous debris.

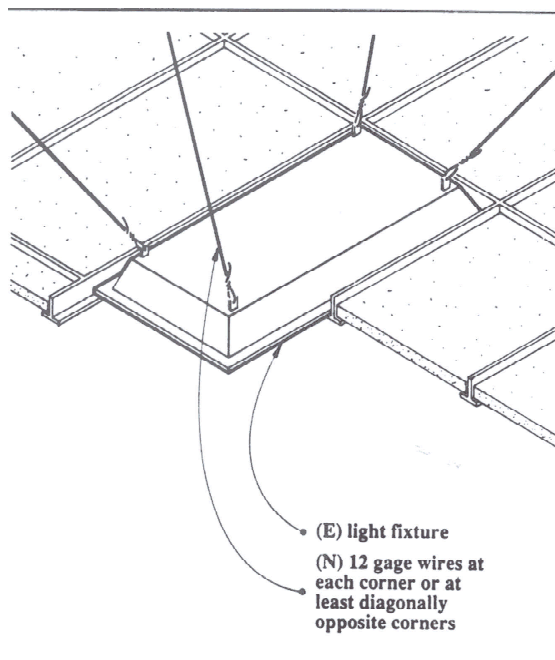
Mitigation Measure

One easy and cost-effective way to protect the glass in your home is to apply adhesive solar film to it. The film may not keep the glass from breaking, but it will prevent the glass from falling onto the floor in sharp shards. The film also will reduce heat and glare, so your home will be more comfortable and your air-conditioning and heating costs will be lowered.



You can secure cabinet doors and kitchen drawers by installing child-proof latches. You can secure light items on shelves by adding a small wooden lip or wires and springs to create an elastic lip. Another way is to use an elastic strap restraint or bungee cord around individual items. Loose shelves should be secured to their wall or shelf brackets. Wooden shelves that rest on wall-mounted brackets may be secured to the brackets with 1/2-inch-long screws. For

light and nonessential items on shelves or countertops, a 1- to 2-inch lip secured to the edge of the counter or shelf may be adequate to keep miscellaneous items from falling off. In this case, individual items do not need to be anchored.



To prevent light fixtures suspended by ceiling grids from falling, you can add independent wire ties connected directly from each fixture corner (or from diagonal corners) to the floor above. For pendant-mounted light fixtures, you can install safety wires to prevent the fixtures from falling, and diagonal wires to prevent them from swaying.

The diagram at left illustrates some of these measures.



Earthquake - 309

Secure your furniture

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Potential Hazard



During an earthquake, large pieces of furniture such as tall bookcases and file cabinets can fall on you or members of your family. Toppled furniture can also block exits and prevent you from escaping. Anchoring furniture so that it remains upright not only helps prevent injuries but also helps protect both the furniture and its contents.

Mitigation Opportunity

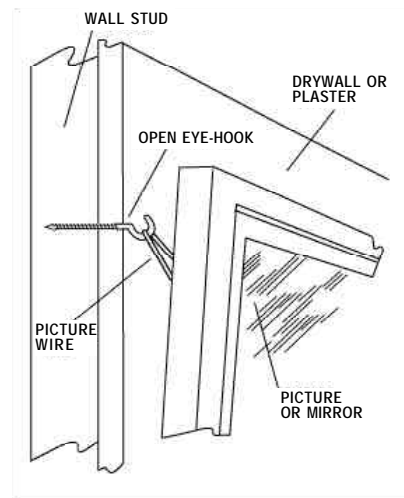
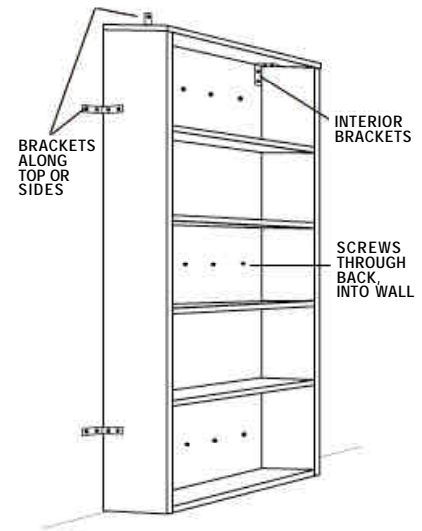
Many furnishings can be anchored, braced, or tethered to an adjacent wall to provide stability in an earthquake. First, locate the structural studs to see that they are near the items you want

anchored. If you have many items to anchor to a stud wall, it may be best to install a mounting strip so you avoid having to relocate items so they will line up with studs. A mounting strip is a horizontal piece of wood mounted to the wall and anchored to each stud. It may be constructed of structural-grade wood 2x4 or 2x6 or a continuous steel channel or angle. The mounting strip should be located at or near the top of the items you want to anchor.

You can anchor large pieces of furniture in several ways. Either bolt directly through the back of the furniture into the wall studs or use steel angle brackets. Do not use Gypsum board and most other interior wall coverings, which pull away easily from a wall. A toggle bolt or nail will also pull out during an earthquake and leave a hole in the wall. If essential contents are to be secured, the shelf or mounting surface should be secured prior to anchoring.

Attach a steel angle to wood studs using a minimum 1/4-inch-diameter by 3-inch lag bolt. Embed the bolt at least two inches into the wood stud. Attach steel angle to metal studs using #12 sheet-metal screws long enough to penetrate the flange material. Use two screws per connection, located 3 inches apart vertically.

For mounting strips, use #14 flat-head wood screws with countersunk heads, with at least 2 inches embedded into the wood stud behind the wall covering. Locate screws along the centerline of the 2x4 or 2x6, and anchor the strip to each stud with a maximum spacing of 24 inches on center. For attachments to the mounting strip, do not screw or bolt anything within 1 inch of each edge of a wood member.



Notes:



Earthquake - 310

Improve the securing of your wall sheathing

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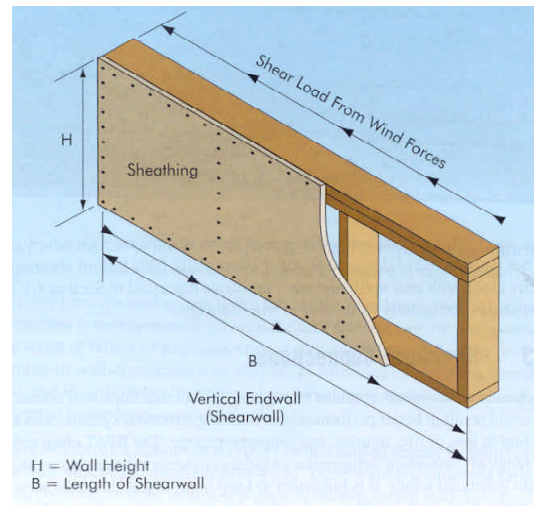
During an earthquake, building structures are distorted as they bend from side to side in response to the earthquake forces. For example, the top of a tall apartment building may lean



over a few feet in each direction. Building exterior walls are subject to horizontal forces. The building's shear walls absorb some of the loads imposed upon the building as a result of these distortions and transfer those loads to other members. If the shear wall cannot take the load, the wall may collapse. If not properly fastened to the structure of the building, the walls, interior and exterior, walls can fall down. Some homes do not have shear walls, which are typically sandwiched

Mitigation Measure

Notes:



Unit 3: Recognize the Risks and Mitigation Measures

Notes	Earthquake Exercise Sheet
Assess Earthquake Risk	Participants look at pictures of potential risks and identify the appropriate mitigation measures by putting the corresponding numbers from the Action Checklist on the answer sheet.

Earthquake Answer Sheet	
Picture Number	Action Checklist Number
1	
2	
3	
4	
5	
6	
7	
8	

Verify Mastery	Discuss responses.
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Earthquake Risk No. 1



Earthquake Risk No. 2



Earthquake Risk No. 3



Earthquake Risk No. 4



Earthquake Risk No. 5



Earthquake Risk No. 6



Earthquake Risk No. 7



Earthquake Risk No. 8



Unit 3: Recognize the Risks and Mitigation Measures

	Earthquake Exercise Sheet Answer Key
	The answers below are only possible, not definite. Encourage participants to identify potential hidden risks that may necessarily be visible in the photo.

Earthquake Answer Sheet	
Picture Number	Action Checklist Number
1	301, 306, 308, 309
2	301, 303
3	(None really)
4	302
5	303, 308, 309
6	302, 309
7	301, 306, 308
8	309